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EXPERIENCES WITH ENVIRONMENTAL CONTROL IN HOT NURSERIES

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ABSTRACT

Various temperature control systems were tested for their ability to maintain a temperature set point in four swine nursery rooms. Wide ranges in temperature were typical. Causes of large temperature swings were attributed to slow sensor sensitivity and oversized heating and ventilating staging. Mixing and matching of equipment for a final system design can result in poor temperature control. Fine tuning of the system can be achieved with some simple monitoring equipment. In some cases, new controls will have to be used to achieve closer temperature regulation.

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INTRODUCTION

Maintaining an even temperature in swine nursery rooms is important for the health and performance of the young pigs. Most designers of such rooms would hope for a temperature fluctuation of no more than 1 1/2 C° from set point temperature.
British work, as sited in International Pigletter (June, 1987) confirms that relatively small variations in temperature influences performance significantly as shown in Table 1.

Table 1. The Effect of Temperature Variation in the first two weeks after weaning on Pig Performance in Flat Decks

	Variable (more than 2C° from set point temperature)	Steady (within 2C° of set point temperature)
Number of pigs	2232	1001
Av. daily gain (g/day)	306	344
Feed Conversion Ratio	1.45	1.17

Temperature variations of more than 2C° from set point reduced the average daily gain by 11% while the feed conversion ration deteriorated by 24%.

In this study, we wanted to determine the temperature control capabilities of a variety of thermostats and control systems that are commonly used on Ontario swine farms. A four room hot nursery had recently been built close to Guelph in which the operator agreed to install a different set of fans and controls in each room. Monitoring equipment was installed to record the temperatures in the rooms, in the hallway and outside and to record electrical heating consumption.

Physical Room Characteristics:

The barn and room layouts are as shown in Figures 1 to 4.

Each room has 6 pens, 3 per side and was operated on an all-in (7 kg, 4 wks.), all-out (16 kgs, 8 wks.) basis. Pen sizes were 1500 x 1500 mm, with one litter (approximately 9 pigs) per pen. Overall room dimensions were 4500 x 3900 x 2700 mm.

Ventilation - Air Inlets:

Minimum ventilation air is supplied via the attic of an adjacent building into the feed room in which there is a 5 kW heater with an internal thermostat set at about 5 °C. A second similar heater is located in the short hallway ser-

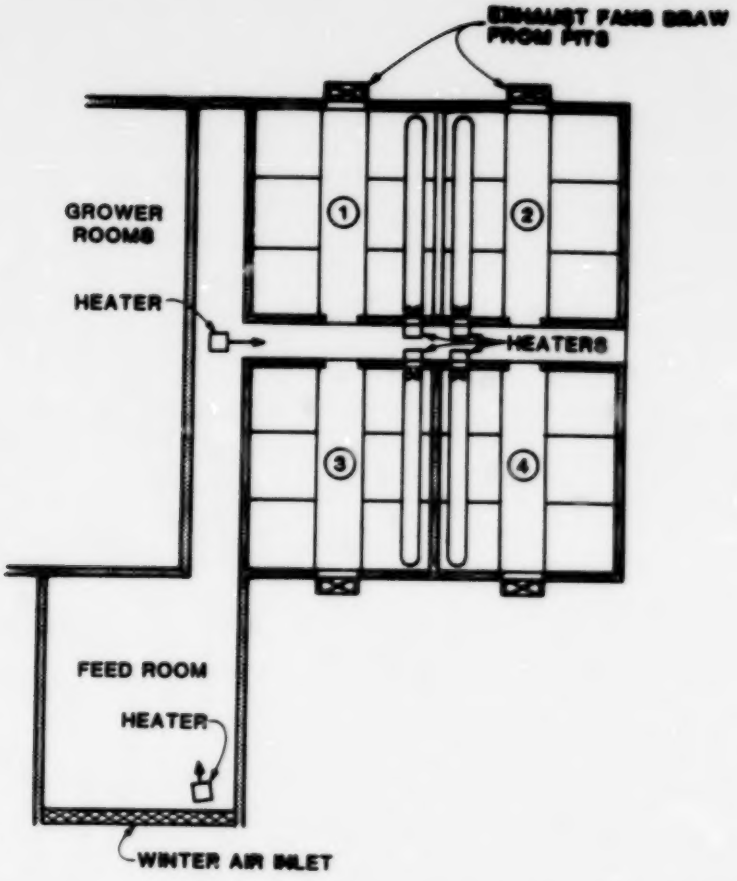


FIGURE 1: PLAN VIEW OF FOUR WEANLING ROOMS

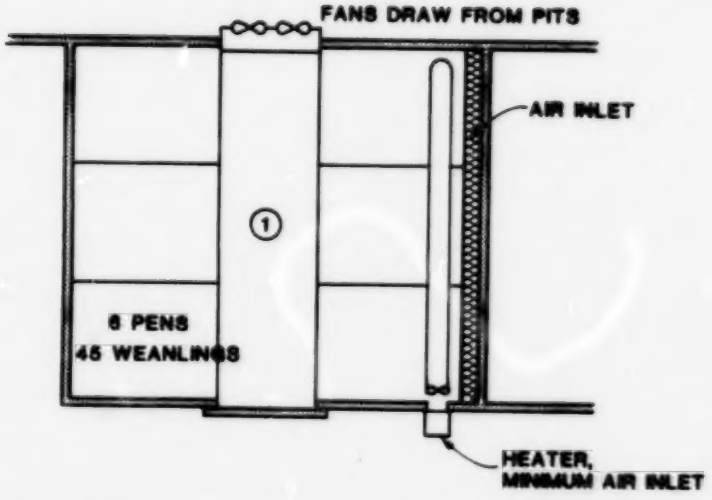


FIGURE 2: PLAN VIEW OF WEANLING ROOM 1 (TYPICAL)

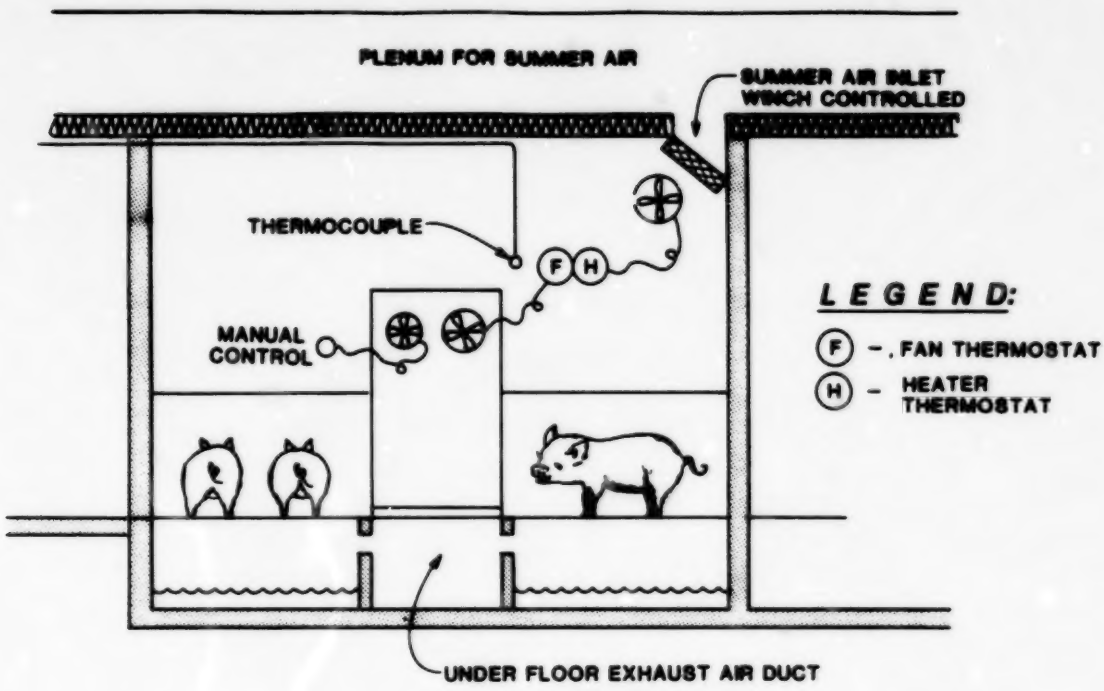


FIGURE 3: CROSSECTION WEANLING ROOM 1 (TYPICAL)

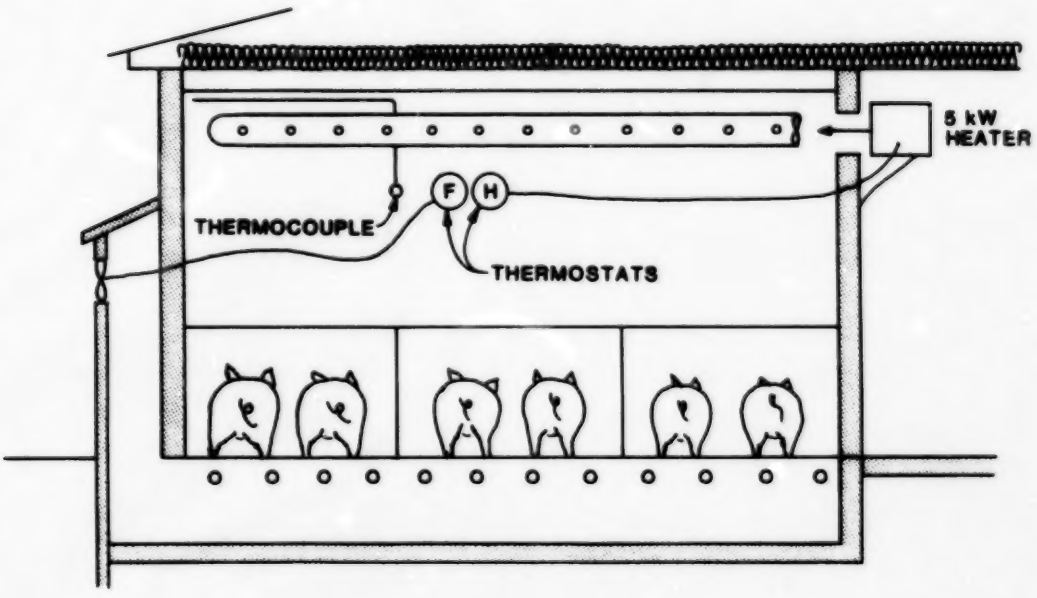


FIGURE 4: LONGNITUDINAL SECTION WEANLING ROOM 1 (TYPICAL)

vicing the nursery rooms. This preheated air is further warmed as it is drawn through a 5 kW heater located just in front of the inlet opening to each room (refer to Figure 1). The inlet openings are about 0.04 m^2 in area and provide sufficient inlet for incoming temperatures below 24°C. These heaters are controlled by thermostats or heater interlocked sensors located in the centre of their respective room.

As the air enters the room, it is immediately mixed and recirculated via a 200 mm PVC recirculation tube running the length of the room. Additional ventilation air is supplied via a winch controlled side air inlet immediately above the recirculation tube and are only openned in hot weather.

Method:

Temperatures were measured using T-type thermocouples. They were located as follows:

- outside ambient
- preheat hallway
- one per room adjacent to thermostat sensors

Temperatures were recorded using a Campbell-Scientific CR-7 Data Logger. At 30 second intervals, all temperatures were read. At 3 minute intervals, the results were averaged and recorded on magnetic tape. The data was then transferred to an IBM-XT for analysis and graphing.

Each room heater plus the two preheat hallway heaters had hour meters installed to record cumulative operating time. Air flow measurements were made during two different site visits using an Alnor balometer. No records of pig health, feed conversion etc. were recorded as monitoring temperature regulation was the primary goal.

Rooms 1, 3 and 4 each had a Kalglo manual variable speed on the 200 mm AAA fan. The control was set at "2" on the dial for very young pigs, which provided about 150 L/s, a relatively high rate for this number of pigs. This could be increased as management required, based on apparent odour levels in the room. Typically, however, it was rarely adjusted up as the temperature control fan provided additional ventilation that satisfied fresh air requirments as the pigs grew in size.

All fans, including the minimum ventilation fans, were AAA Mini Brutes. All manual variable speed controllers were Kalglo.

SYSTEM DESIGNS AND RESULTS

A Honeywell Modufan

- 200 mm fan on manual variable control for minimum continuous ventilation

- Honeywell T731 Modufan on 350 mm fan, wired in fan-auto mode (low temperature cut-out)

- 5 kW heater controlled by a Honeywell T631G

Three different Modufans were installed, including one supplied directly by the manufacturer. Each one resulted in the same problem; the Modufan could only provide full power or none to the 350 mm fan, essentially operating as a single speed thermostat. Poor temperature control resulted and the tests were discontinued.

B AAA Variable Speed

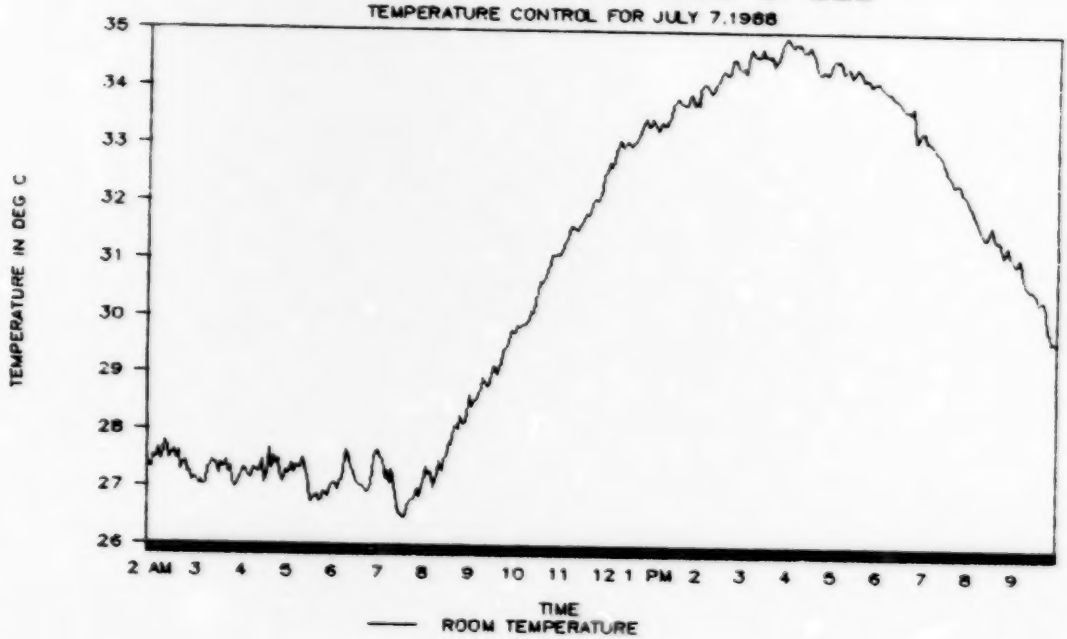
- 200 mm fan on manual variable speed control for minimum continuous ventilation

- Honeywell T631G used to interlock the 5 kW heater and the 350 mm fan, using the temperature differential between low and high as a deadband

- The AAA variable speed was used to vary the 350 mm fan once power was supplied via high speed on the Honeywell TG31G

This controller and control system in general performed satisfactorily. Typical results from warm weather operation are presented in Figure 5.

FIGURE 5: AAA VARIABLE SPEED



C **Fan International 5 Speed**

- 200 mm fan on manual variable speed control for minimum continuous ventilation

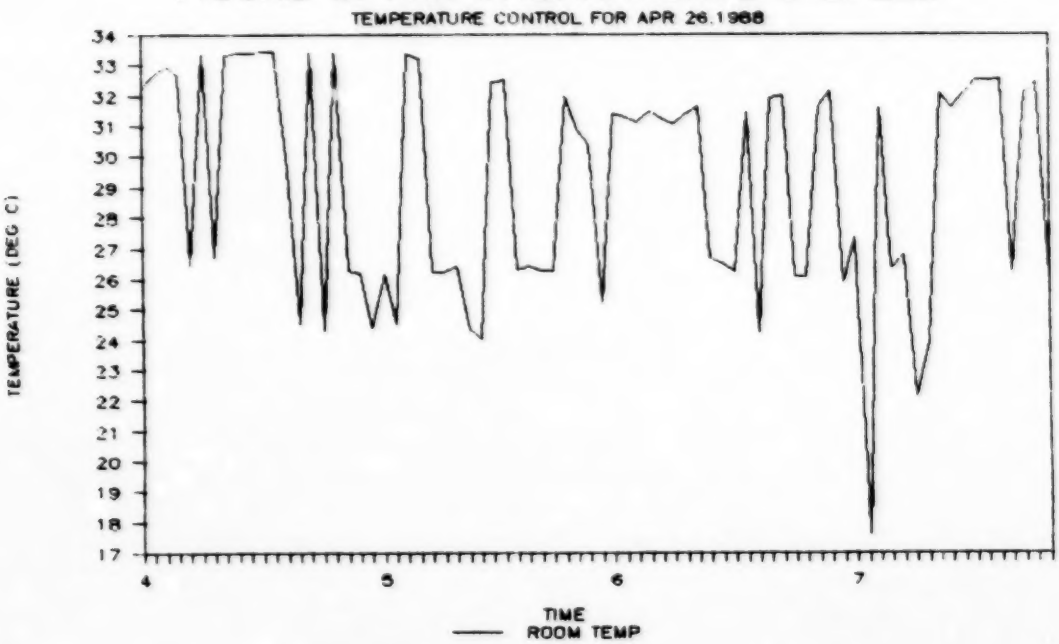
- Honeywell TG31G used to interlock the 5 kW heater and the 350 mm fan, using the temperature differential between low and high as a deadband

- The Fan International control was used to vary the 350 mm fan once power was supplied via high speed on the Honeywell TG31G

This control system provided unacceptable temperature control. This was due to the large jump in ventilation flow rate that occurred when the 350 mm fan came on low. The jump was from about 150 L/s (200 mm fan continuous) to about 620 L/s (200 mm fan at 150 L/s + 350 mm fan on low at 470 L/s).

Figure 6 shows typical results from the 350 mm fan cycling from off to low.

FIGURE 6: FAN INTERNATIONAL 5 SPEED



D ALPHA BC01-T (Room 1)

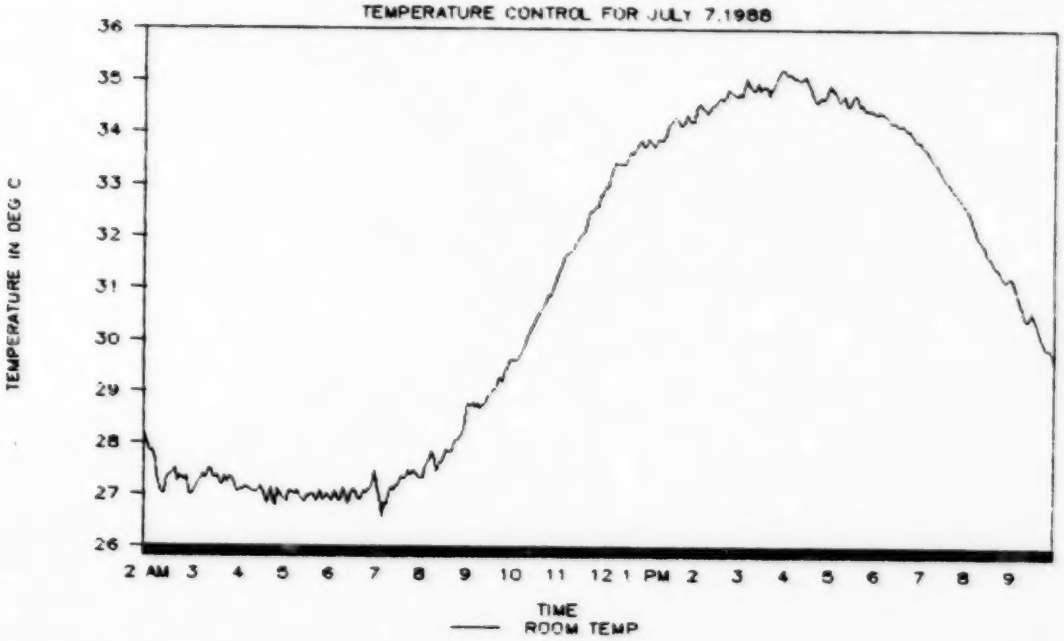
The BC01-T sequential controller sequenced on fans as follows:

STAGE	FAN	AIRFLOW ADDED	TOTAL AIRFLOW
	(diameter in mm)	(L/S)	(L/S)
1 (cont.)	180	70	70
2	200	200	270
3	200	200	470
4	350	400	870

- The 5 kW heater was controlled by a built-in interlock on the BC01-T

Results from this system were generally good as shown in Figure 7 from warm weather operation. Cold weather operation was also good.

FIGURE 7: ALPHA BC01-T



E ALPHA MC01-T and ALPHA AC01-T

This system was tested in two different modes:

1. ALPHA MC01-T

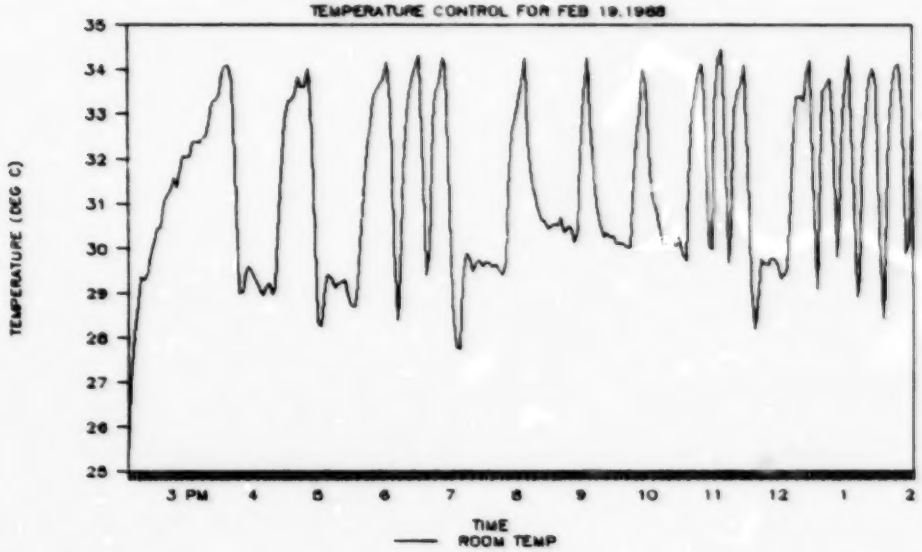
- 200 mm fan on manual variable speed control for minimum continuous ventilation
- ALPHA MC01-T wired for low temperature cut-out on 350 mm fan
-5 kW heater controlled by a built-in interlock on the MC01-T

This control system provided unacceptable temperature control. This was due to the following:

- When room temperature rose and the ALPHA MC01-T activated the 350 mm fan, the ventilation rate rose from about 150 L/S (200 mm fan continuous) to about 300 L/S (200 mm fan at 150 L/S plus 350 mm fan at 150 L/S). This was a satisfactory increase. However, the 350 mm fan speed continued to increase until total flow rate was approximately 500 L/S. This cooled the room below set point. Once the controller received the signal that temperature was too low, the controller would abruptly turn off the 350 mm and turn on the 5 kW heater.

Typical results from this control system are shown in Figure 8. As this was unacceptable, the control was changed by the Alpha dealer as discussed under 2.

FIGURE 8:ALPHA MCO1—T

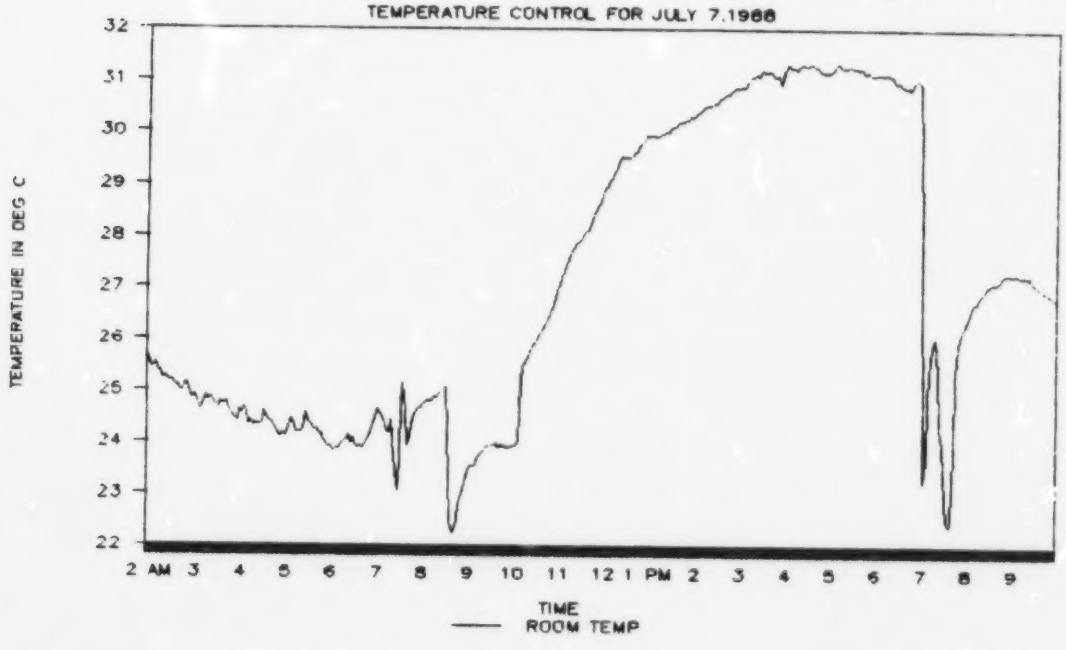


ALPHA MC01-T AND ALPHA AC01-T

- 200 mm fan controlled by ALPHA MC01-T for minimum continuous operation plus variable speed control
- 5 kW heater controlled by interlock on ALPHA MC01-T
- 350 mm fan controlled by AC01-T with low temperature cut-out, connected to the MC01-T

Temperature control from this system appears to be much more acceptable. However, a full year of testing has not been concluded. Results from warm weather operations are shown in Figure 9.

FIGURE 9: ALPHA MC01-T & ALPHA AC01-T



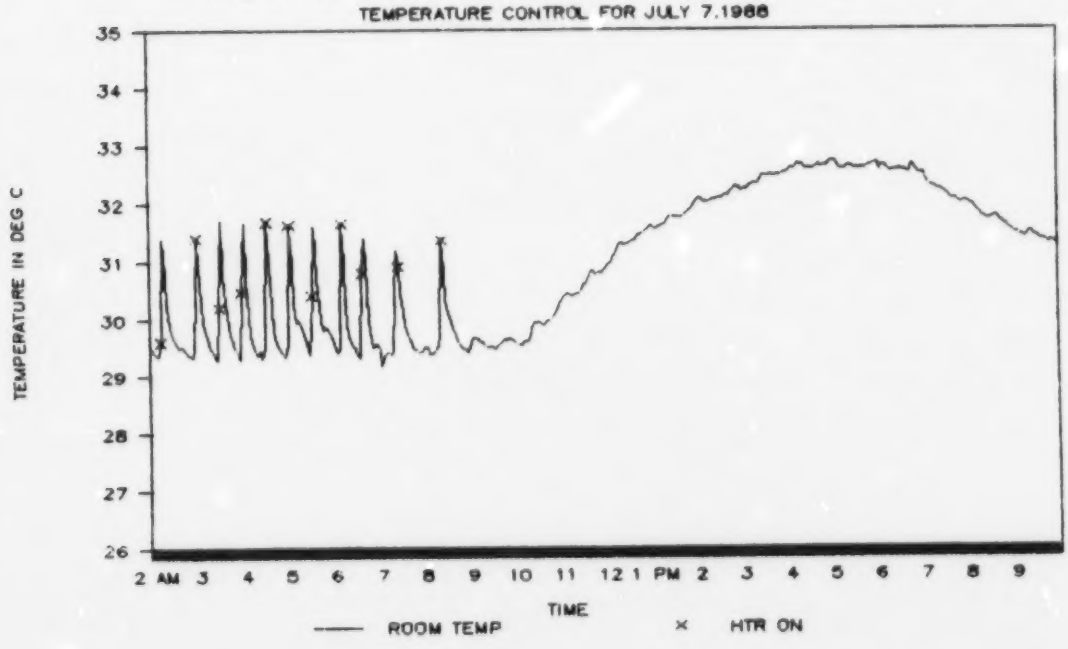
F PHASON

-200 mm fan on manual variable speed control for minimum continuous ventilation
- Honeywell T631G used to interlock the 5 kW heater and the 350 mm fan, using the temperature differential between low and high as a deadband
- AAA variable speed was used to vary the 350 mm fan once power was supplied via high speed on the Honeywell TG31G

Results from this system have been good to date. However, as it was placed in the room where the Fan International system was installed, only warm weather data is available. Figure 10 shows typical results.

Note the X marks on the graph signify the middle point of heater-on time periods. Obviously, the Honeywell T631G was controlling the heater only, and not until approximately 9:00 AM did the Phason controller take over. Warmer outside temperatures dictated temperatures in the room shortly after
10:00 AM.

FIGURE 10: PHASON VARIABLE SPEED



SYSTEM CONTROL COSTS

Table 2 indicates the various prices for the individual control systems.

TABLE 2: SYSTEM CONTROL COSTS

	MIN. FAN CONTROL	OTHER FAN(S) CONTROL	HEATER INTERLOCK?	MAIN CONTROL COST	TOTAL CONTROL COST
(A)	MANUAL-200 mm	MODUFAN-350 mm	ON H.WELL TG31G	$138	$400
(B)	MANUAL-200 mm	AAA-350 mm	ON H.WELL TG31G	$130	$400
(C)	MANUAL-200 mm	5SPEED-350 mm	ON H.WELL	$250	$530
(D)1	MANUAL-200 mm	MC01-T-350 mm	BUILT-IN	$500	$650
2	MC01-T-200 mm	AC01-T-350 mm	BUILT-IN	$850	$850
(E)	BC01-T-180 mm	BC01-T-200mm(2) plus-250mm(1)	BUILT-IN	$1000	$1000
(F)	MANUAL- 200 mm	PHASON - 350 mm	ON H.WELL T631G	$130	$400

NOTES:

- KALGLO Manual variable speed cost = $150
- Additional fans required for BC01-T system which will increase system cost
- Honeywell TG31G thermostat cost = $130
- Prices as of July, 1988

HEATER USE

The results from heater electrical useage are not presented. It became apparent after the tests began that there were large differences in the actual minimum ventilation rate from each room. This discrepancy would mask any differences between thermostats in conserving heating energy.

However, it was a useful tool for the operator. It did point out to him that one room was taking considerably more energy than another although it did not tell him why. It convinced us that an cumulative hour meter on heating devices will at least make the operator aware of how much energy is being used in various areas.

CONCLUSIONS

Our goal was not a definitive test of thermostats. The recently published PAMI report, which was not available during our study, is an excellent reference on the quality of specific thermostats. We were simply looking at a variety of commonly available thermostats and control systems to learn what we could about how they were working under similar conditions in a farm situation.

We can conclude the following:

- temperature fluctuations were higher than expected for these hot nurseries
- the cause of this was attributed to one or more of the following:
    - : slow sensitivity of room sensors to varying room conditions
    - : heater control or interlock
    - : equipment staging both in heating and fan modes

In essence, the entire ventilation and control system needs analysis on a continuing basis for equipment that is all too often 'mix and match'. Fine tuning of existing controls, or in drastic cases, a complete change, is required.

RECOMMENDATIONS

1. There is a strong need for temperature monitoring beyond what is offered by simple maximum-minimum thermometers. Operators who have access to data such as the graphs in this paper or from recording thermographs are more aware of what there ventilation system is doing.

2. The use of the cumulative hour meters on heaters can be used as a management tool for analysing system performance over larger term operating periods, particularly when other systems can be compared.

3. A combination of controller sensor sensitivity and equipment sizing (ie. staging of heating/ventilating) is the major problem in room temperature control. Where poor temperature control is suspected, these two components should be analyzed.

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